51st European Congress of the Regional Science Association International

37th Spanish Regional Science Association Conference

Barcelona (Spain), August 30 to September 3, 2011

Special Session: Industrial Districts and Clusters Facing Globalisation

IDENTIFICATION OF TECHNOLOGICAL DISTRICTS: THE CASE OF SPAIN

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Abstract

In recent years, several contributions have been focused on a new sort of productive systems that share some characteristics with Marshallian industrial districts. These contributions have analysed the competitiveness of these new areas and how have been promoted by policy makers. In this line, the Marshallian concept of industrial district has been increasingly related to high technology and innovation in order to analysis technological districts or clusters. The aim of this research is to show how these new areas have characteristics are not similar to those shown by traditional industrial districts. Therefore, framework and techniques for analysis that have been traditionally used for industrial districts must be adapted for identifying technological districts. Specifically, some reflections about the framework analysis of sector and spatial units are introduced in the first part of this research as well as those techniques that can be useful to identify and analyse technological districts. Next, the analysis is focused on the identification of technological districts in Spain. A multivariate analysis will be

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applied to calculate a synthetic index that will be used to identify those areas with a high degree of specialization in high and medium technology activities. This synthetic index will collect data about those technological activities that are involved not only in manufacturing but also in activities of innovation and R&D. Until now, there have been not many attempts to identify technological clusters through the application of quantitative methodologies; therefore, the purpose of this research is to contribute to the enhancement of knowledge about these areas in Spain.
Keywords: technological districts, clusters, location, spatial agglomerations.

1. Technological Districts and Clusters: Conceptual framework

During the last thirty years, literature about models of industrial development has emerged inside Industrial Economics. These models are based on specialized productive agglomerations and how these agglomerations have influence in economic development. These contributions have tried to enhance the knowledge about the positive effects of industrial agglomerations for firms and for, also, the territory and how these agglomerations are organized. Agglomeration economies and external economies are the main arguments that can explain the optimal performance of industrial agglomerations.

The origins are the pioneer ideas of Alfred Marshall (1890) about the advantages of agglomerations of firms and subsequent theories that explain mechanisms behind the process of agglomeration of economic activities. Such theories were introduced in researchs about regional and development economics by economists as Isard (1956), Myrdal (1957), Perroux (1950) and Hirschman (1958). These ideas and theories have been the starting point to create models in order to explain the raising and running of firm agglomerations. Thus, the Industrial District Theory has been developed since the 70's to explain the advantages shown in some Italian regions, especially in the north-east and the centre (Becattini, 1979, 1989, 1992; Bellandi, 1986; Sforzi, 1987, 1992; Brusco, 1992; Triglia, 1993; Signorini, 1994; Dei Ottati, 1995). These advantages were linked with the existence of elements as an industrial specialization, interactions and exchanges between small firms inside a local agglomeration, a qualified local labour market and business support activities that can increase the productivity of firms and improve their competitiveness. Theory of industrial districts stands out the homogeneity of social and productive structure as a key element because it facilitates communication and interactions between social and economic agents. Through these interactions local firms can achieve a collective efficiency that can be defined as a comparative advantage. The latter is originated from a combination of external economies and a united action (Ravelloti and Schimtz, 1999).

In line with these ideas, there are other approaches focused on the efficiency of territorial systems of firms as local productive systems (Garofoli, 1992), flexible specialization model and new industrial spaces (Pecqueur, 1989; Courlet and Pecquer, 1992; Pyke et al., 1990; Sabel, 1989; Scott, 1988). These theories try to explain the changes in the industrial structure in the 1980's due to the crisis of fordism model. The increase of flexibility inside firms leaded to a vertical disintegration of organizational structures giving place to a process of convergence and spatial concentration of firms in a same location. Therefore, geographical concentrations of small firms took form as systems characterized by their self-organization capacity and cooperation links. These elements are on the base of a high level of flexibility and efficiency in production activities and gaining access to markets.

Subsequently, theories about competitive advantages of nations and regions (Porter, 1998, 2001; Dunning, 1998; Alburquerque, 1996) focus on the benefits from the development of clusters. These clusters are defined as a group of interlinked industries that are surrounded by business support firms. Externalities, synergies, cooperation and technology diffusion are promoted through links between industries and services firms. Thus, an important number of researchers and scholars focused on the concept of cluster linking this concept to innovation and regional competitiveness. These contributions are not limited to traditional industrial sectors, mainly related to industrial districts, but also analysis are spread to high technology industry and services. The results of these analysis show how industrial districts can be considered as a special case of cluster (Lazzeretti, 2006).

These theories have previously highlighted externalities as an element that arise because the geographical concentration of activities. In addition externalities are determinant in the dynamic process of agglomeration of economic activities and in the economic development of the territory (Callejón and Costa, 1996; Beaudry and Swan, 2001; Glaeser et al., 1992; Henderson, Kunkoro and Turner, 1995; Callejón, 2003). In the 90's, New Economic Geography introduced factors as human capital, knowledge and infrastructures (Krugman, 1990; Fujita et al, 2000) in order to explain the links between agglomeration of activities and regional development.

In addition to this group of theories there are other approaches that have stressed on the role played by technological innovation and agglomeration to generate competitive advantages in a territory and economic benefits for firms, industrial sectors and the whole economic system. Thus, theories of innovation factors and innovation networks (Aydalot, 1986; Camagni, 1989, 1991; Maillat, 1995) together with regional innovation systems (Iammarino and McCann, 2005; Lundvall 1992; Braczyck, Cooke and Heidenreich, 1996; Cook and Morgan, 1994; Cooke, Gómez Uranga and Etxebarría, 1997) analyse the direct relationship between the success of some productive systems and their capacity to produce and introduce innovations as well as to spread them. These studies strengthen the idea of innovation processes where several agents can produce, transmit and/or use knowledge together with institutions that can regulate this flow of knowledge. In this process, geographical proximity, common principles of organization shared by firms and same culture are key elements in the creation of networks to transmit tacit knowledge. This type of knowledge is hard to codify but is essential in the process of innovation (Méndez, 2006).

A usual aspect of these models about agglomeration of firms and the origins of territorial systems is the hypothesis that enterprises and sectors are not considered individually. These two elements are part of a system that has influence over the operating modus, the efficiency and the results of the whole group of firms. Intense interactions and cooperation links between agents from different activities, not necessary to be part of the same industrial sector, are factors that have positive effects on the competitiveness of these areas. Also, it must be considered the important role played by entrepreneurship organizations and institutions in the development of R&D activities or financial activities. In general, for all these types of organization of production, innovation and knowledge are main forces driving the creation of clusters and similar firm agglomerations as well as their evolution and development.

Following these arguments, concept of industrial district has been related in recent years to high technology and innovation activities although this concept has traditionally been defined for traditional industrial activities. Thus, it has become frequent the use of expressions as "emerging district or cluster", "technological district" or "strategic district". These new concepts refer to heterogeneous agglomerations of industrial and services firms but directly connected with activities that are intense in innovation, technology or knowledge. Clusters and industrial districts that are specialized in high technology activities as information and communication technologies (ICT), biotechnology, aeronautical or nanotechnology are some examples. In Spain, clusters of high technology activities have appeared[2] in the last years because firms of these sectors tend to be spatially concentrated because their needs of flows of high quality information and advanced training services. In order to have a quick and easy access to these elements firms tend to minimize information costs concentrating in the territory. Also, firms obtain advantages because the existence of specialized and highly qualified labour markets and strong networks of backwards and forwards links related to

[2] For example, aeronautical clusters (Madrid, Valencia, Basque Country, Andalusia, Aragón); TIC clusters (Navarra, Asturias, Galicia, Catalonia, Basque Country and Madrid); biotechnology clusters (Madrid, Balearic Islands and Andalusia).

production and innovation (i.e. suppliers, technological or financial services, clients or distribution hubs). If clusters appeared in Spain through the concentration of high technology firms, spin-off firms have been the result of the spatial agglomeration increasing the degree of concentration because these new entrepreneurs usually decide to locate near their old firms (Keeble, 1988; Ciciotti, 1993). Also, clusters can improve the efficiency of innovation systems due to the spatial concentration of different agents (firms, public and private research centres or training firms). These agents are involved in technological and innovation projects that make an important contribution to the development and diffusion of new technologies and, also, are the base for future R&D projects (Camagni, 1991; Audretsch and Feldman, 1996; Russo, 2002; Cooke, Heidenreich and Braczyk, 2004).

Together with the formation of high-tech specialized areas, there are other examples where the development of technological districts or clusters is related to some activities inside traditional industrial sectors. This would be the case of districts specialized in technical textiles (used in other sectors as aeronautical or nautical industries, as a material for acoustic or temperature control, anti-vibrations, textiles with applications in medicine,…) or in intelligent plastics (with shape memory or changing shape depending on temperature or light,…). Clusters of French region of Rhône-Alpes are examples of this type of agglomerations. This region shows a high technology industrial level because the intense relationships between firms (independently of size), universities and centres with high quality research activities[3]. A *Competitiveness Cluster* (following the definition of the French industrial policy) has been developed in this region through the promotion of relationships between high-tech firms (biotechnology, nanotechnology, medical devices) and traditional firms manufacturing plastic products, precision mechanics or textiles (Darmon and Jacquet, 2005; Mazzeo, 2006, Benko, 2006). In this way, there can be identified clusters related to textiles industry (Techtera[4] and Uptex[5], clusters specialized in technical textiles) and plastic products industry (Plastipolis[6], specialized in plastic engineering and sensorial properties of plastics).

[3] Clusters identified in this region: 14 research clusters; 15 "Competitiveness Clusters" and 10 regional clusters "Rhône-Alpes" with the aim of fostering the competitiveness of enterprises.

[4] This cluster pretends to increase the use of technical textiles in most of the strategic French sectors as healthcare, wearing apparel, building or transport.

[5] The objective of this cluster is to reinforce the competitiveness of firms specialized in technical textiles innovating in new characteristics and applications of these materials.

[6] Innovation in production processes, intermediate inputs, intelligent plastics or biodegradable food packaging is the main challenge of this cluster.

Despite the difficulty to define clearly a technological district this concept can be useful as policy instrument. Therefore, technological districts can be a policy tool to improve and strengthen the productive structure of industry. This would be an answer to the problems that traditional industrial sectors are nowadays suffering as a consequence of the intense international competition and obsolete industrial structures. So, policy support to technological districts could improve not only the performance of some industrial activities but also the economic potential of these areas.

Therefore, in this research the objective is to identify technological districts in Spain enhancing the knowledge about these areas. Specifically, the aim is to identify areas with a high concentration of firms and institutions involved in activities as manufacturing and development of new technologies, innovation and knowledge. To achieve the main objective, it becomes necessary to introduce some questions related to the definition and scope of sectors and territories as well as which techniques can be used to identify technological districts. In that sense, techniques and criteria that have been traditionally used for industrial districts must be adapted to reflect the changes in these new industrial agglomerations. The next section reviews empirical literature about the identification of industrial and technological districts in several countries.

2. Theoretical review about technological districts

The literature about industrial districts is also the theoretical background for technological districts. Although industrial districts are mainly associated with traditional manufacturing sectors several empirical studies point to the existence of technological districts or science districts. In fact, different classifications include technological districts as a specific case of industrial district (Zagnoli, 1993; Storper, 1992). In this context, the taxonomy of local or territorial systems of Markusen (1996) is based on the interactions between firms and institutions. These interactions depend on not only geographical proximity but also on organizational structure. Markusen's taxonomy has four categories: industrial districts, hub and spoke district, satellite platforms or systems and state-anchored (public sector systems). Following Lazararic et al (2004), this taxonomy provides an excellent classification of local systems. However, globalization and the growing importance of the knowledge economy have fostered new types of interactions. So, these authors added two new categories to Markusen's taxonomy: technological districts and technopoles. In line with these new contributions, McDonald and Belussi (2002) introduced a new classification using general elements as composition of the industrial structure, number of institutions or support agencies, external relationships of firms and development tendencies. This extended taxonomy includes four types of industrial districts: three endogenous districts (Marshallian, high technology and post-Marshallian districts) and an exogenous district externally controlled (satellite district). Using this classification, Table 1 shows the characteristics of Marshallian (traditional) industrial districts and technological districts.

The development of areas as Silicon Valley or scientific parks in USA, United Kingdom or Taiwan (examples of high technology industrial agglomerations) has been made possible because the strong relationships with public sector (for example, the purchases by governments for military or aerospace programmes) or the relationships with universities or public research centres as the biotechnology district of Cambridge (Cooke and Huggins, 2002; Cooke, 2002). In France, the growth of technological districts or technopoles as Sofía Antipolis or Toulouse has been the result of the efforts made by the whole innovation system (at national and regional level) and the establishment of top-down policies. The evolution of these areas has generated a model of local endogenous development. This model has been reviewed and nowadays has a structure similar to the industrial district theory (Longui, 2002).

Table 1. Taxonomy of industrial districts.

	Marshallian (traditional) Districts	**Technological Districts**
Structure	Predominance of small and medium-sized enterprises (family firms) Internal learning processes using several information and knowledge flows	Diversified firm size Changing networks (not very dense) Relationships between entrepreneurs, scientists and technical staff Intense flows of information and knowledge (decentralized)
Institutional characteristics	Key role of the community (social and economic agents) Trust and cooperation links Support agencies (not necessary)	Key role of the community (social and economic agents) Existence of universities and public and private R&D centres
External relationships	Only commercial relationships Limited external relationships	Strong external relationships specially with knowledge sources
Development tendencies	Gradual process from inside to outside through the increase of relationships with other areas to obtain inputs with higher quality and more competitive prices and to get access to new markets and new knowledge	High growth cluster (in case of success)
Paradigmatic example	Traditional Italian industrial districts	Route 128 and Silicon Valley (USA) Biotechnology Cluster and Silicon Fen in Cambridge (UK)

Source: McDonald and Belussi (2002).

On the other hand, researchers have frequently and indistinctly used concepts of industrial district and cluster. Following Porter's definition of cluster, the Institute for Strategy and Competitiveness of Harvard University has analysed 833 clusters in 53 countries[7]. Results show 105 high technology clusters (12.67%) with electronics and informatics as the most relevant activities (37 and 34 clusters specialized in these technologies, respectively). The spatial distribution of clusters shows a concentration of more than a half of the total number of clusters in USA and UK (36 and 30 clusters). In contrast, 42.9% of high technology clusters is located in Member States of the European Union.

In recent years, interest for technological districts has grown and many contributions have them as main theme. For example, McDonald and Belussi (2002) include several examples of other studies as Chaminade (1999), Charles and Benneworth (2000), European Commission (1998), Hertog and Maltha (1999), Heath (1999) or Kuo and Wang (2001). In the European Union, there has been an increasing concern in mapping clusters in order to enhance the knowledge about these areas. The publication by the European Commission "Regional clusters in Europe" (2002a) includes a quantitative and qualitative analysis of 34 regional clusters in 17 European countries; 14 of them are intensive in technology and/or science-based clusters and are located in 14 Member States. In addition, in 2004 the European Commission carried out a project about entrepreneurship clusters and networks where 84 clusters from 20 European countries were analysed being 25 technology and/or science-based clusters (European Commission, 2004).

In Spain, first efforts to identify industrial districts (MOPU, 1987; AGE, 1988, 1990; Celada, 1988; Costa, 1988, 1992; Ybarra, 1991; Climent, 1997) were followed by studies with a regional perspective. Thus, empirical studies has been done for the Basque Country (Larrea, 2000), Andalusia (Caravaca, 2002) or the Valencian Region (Ybarra, 2009; Ybarra et al., 1998, 2000, 2002; Soler, 2000; Albors and Molina, 2001; Giner and Santa María, 2002). In recent years, Boix and Galleto (2004, 2007), Santa Maria et al (2004), and Ybarra et al (2008) have identified industrial districts using quantitative methodologies. However, these contributions have been mainly focused on the identification of traditional industrial districts; so, there is not enough information about technological districts in Spain. Studies about high technology sectors in Spain

[7] Information is available at the online cluster database "Clusters Profiles" of the Competitiveness and Strategies Institute of Harvard University.

have analysed electronic industry in Madrid Region or the ICT sector in the metropolitan area of Barcelona.

The initial contribution of Benton (1990) was the seed of a research area developed inside the Institute of Economics and Geography of the Spanish National Research Council-CSIC (Rama, 1992, 1999; Suárez and Rama, 1996, 1998; Rama and Melero, 2000; Rama and Calatrava, 2002; Rama et al., 2003). Together with these contributions, there are others that can be cited as Chaminade (2001) who analysed the innovation evolution of ICT clusters in Spain or the analysis of ICT sector in Barcelona (European Commission, 1998, 2002b) and the research by Bosch and Capel (2004). The review of these contributions shows the weakness of innovative dynamism, a lack of intense ties between firms in Madrid and Barcelona and the presence of a strong institutional framework supporting clusters but not well-known and frequently used by firms.

Recent contributions by Giner (2006, 2008a, 2008b) and Giner and Santa María (2009) have been based on the application of quantitative methodologies to identify technological districts in Spain. Pablo et al (2206) introduce a methodology that is designed to infer sectors or activities that can go through a clustering process using as reference analysis of other similar socioeconomic environments. Four potential clusters were identified in Madrid in the following activities: biotechnology, pharmaceutical industry, aerospace industry and ICT.

To sum up, despite the concept of technological districts has its source in the Marshallian industrial district there are important differences between them. An increasing number of researchers have focused in these last ten years on analysing technological districts in different countries. Anyway, technological districts show some characteristics that demand an adjustment of the analysis techniques that have been traditionally used in the identification of industrial districts. In the next section, some reflections about the framework analysis of sector and spatial units are introduced as well as those techniques that can be useful to identify and analyse technological districts

3. Methodology to identify technological districts and clusters

In the last years different methodologies has been used in order to map industrial districts or clusters in the EU and other countries. Researchers and policy-makers have recognized the importance of mapping these areas in order to design specific policy measures.

Methodologies based on quantitative and qualitative information have been used to identify districts and clusters. Quantitative methodologies can be applied to any areas because the availability of data about industrial firms, location and economic variables as employment and the results can be compared at any level. Also, the application of cluster, factorial or correspondence analysis provides information about statistical similarities between regions or other geographical areas. Although the use of qualitative methodologies provides enhanced information it becomes difficult to compare studies based on these methodologies (European Commission, 2003).

Anyway, to apply a methodology to map clusters it becomes necessary to define which classification of economic activities will be selected. In general, official classifications as NACE (for the EU) or CNAE (in Spain) have been frequently used despite the fact that it would be hard to analyse vertical relationships in a sector. Traditionally, the identification of industrial districts of traditional manufacturing activities has been based on whole sectors as footwear manufacturing, textiles or tiles. However, the identification of high technology areas has the problem of considering activities that are included in different economic groups; therefore, sectoral delimitation could be more complex to concrete. For example, the analysis of the ICT sector implies to deal with industrial sectors (i.e. the manufacture of electronic devices) and service activities (i.e. telecommunication services, e-business or e-commerce services) or the group of biotechnology activities includes so different sectors[8] as pharmaceutical products (new medicaments*)* and manufacturing of plastics products (food packaging). In other cases, there is no definition of some new economic activities. For example, technical textiles can't be found on any of the two groups related to this industry (textiles and wearing apparel).

Therefore, the identification of technological districts using traditional methodologies becomes a complex task because the difficulty to manage many sectors and the lack of data for the most newly industrial and services activities.

In addition, the problem of territorial units must be considered. In general, most of the official databases are constructed using administrative divisions being this an important limitation (Viladecans, 2001) because clusters and districts are composed of several units (i.e. municipalities). To solve this problem, local labour markets or travel-to-work

[8] Biotechnology firms in the Valencian Region are classified in at least more than 10 different economic activities as manufacturing of pharmacy products, medical equipment and devices or fertilizers and nitrogen compounds (Giner and Santa María, 2009).

areas are useful functional geographical units[9] (Smart, 1974; Coombes and Openshaw, 1981). Local labour markets have been estimated in countries as Spain or Italy calculating the commuting flows of workers from home-to-work to delimitate territorial units that have been used to identify industrial districts[10]. So, flows of people between towns that are part of the same local labour market increase social and economic interactions being this area suitable for the identification of industrial districts (Sforzi, 1989).

However, geographical distance is less important in the identification of technological districts, so, this process is more complex in order to select a spatial unit of analysis. Cooperation networks that spread beyond even national frontiers are frequent in activities as aeronautic manufacturing, electronics or biotechnology[11]. For example, the Southern European Cluster in Photonics and Optics (SECPhO) has been recently created in Catalonia with the participation of other Southern European regions[12].

In addition, traditional industrial districts are located in groups of medium-sized municipalities, even rural municipalities, whereas the evidence about technological districts shows how these tend to be located in big urban areas or metropolitan areas. So, location of technological districts must be analysed looking for agglomerations of high technology industrial and services firms inside urban areas with a predominance of other industrial and services activities than those related to high technology. Therefore, new techniques must be introduced to analysis the location of high technology activities in urban areas as micro-localization technique based on the analysis of geographical coordinates of firm locations using GIS (Geographical Information Systems) databases. An example of high technology urban area is the 22@Barcelona district[13]. In this district of the city of Barcelona are concentrated technological firms, universities, training centres and research institutions and other agents that facilitate flows of information and relationships between these agents (Mascarilla, 2008).

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9 Daily commutations (to workplace, shopping and other reasons) as well as phone calls are spatial variables used to delimitate functional regions.

10 Local Labour Systems (LLS) have been used in Italy to identify industrial districts (ISTAT, 1996, 1997, 2005 and 2006) as well as in Spain (Boix and Galleto, 2004 and 2007) or in France (Lainé, 2000) where local labour areas were jointly defined by the French Ministry of Labour and the National Statistical Institute (INSEE).

11 In Spain the regions of Catalonia, Madrid, Basque Country and Valencia have created a BioRegion network to generate synergies and flows of knowledge and information about best practices.

12 Firms and R&D centres of this cluster represent more than 50% of the Spanish sector related to Optics and Photonics.

13 22@Barcelona district is made up of clusters of different activities as ICT, multimedia, medical technologies or energy.

Spatial econometrics techniques can be also used to analyse industrial activities in metropolitan areas. Indicators as Local Indicator of Spatial Association (LISA) can be applied to obtain information about the relevance of a variable that have similar values in neighbour areas. So, characteristics associated to technological districts demand new approaches to select the accurate spatial units to identify these new productive areas.

Once reviewed main aspects about how to define a sector and geographical limits of spatial units to identify technological districts, next step must be to go over research methodologies used to identify areas of productive specialization and how these can be applied for technological districts. In general, research methodologies have defined several criteria to test the existence of advantages created by agglomerations of firms (Giovanneti et al, 2005). Territorial concentration of firms that can show a high productive specialization is one of the most used characteristics to measure agglomeration economies. This variable is calculated using well-known indicators as Gini Index, Herfindhal-Hirschman Index, Ellison-Glaeser Index, Location Quotient or the Standardized Location Quotient proposed by O'Donogue and Gleave (2004). In most of the empirical contributions about mapping of industrial districts other basic variables as specialization degree, number and size of firms have been used to construct identification criteria. Firm size distribution must be carefully analysed because heterogeneous distributions are associated to hierarchical structures whereas homogeneous firm size is usually related to a tendency to cooperate and, therefore, to generate agglomeration economies. However, it might be explained that quantitative expressions of identification criteria have been discretionally established and, therefore, the result of mapping process can change depending on the selected methodology. For example, the Porter methodology to identify clusters is based on the calculation of indicators (location quotient, employment percentages and regional employment correlations between sectors) and their cut-off values are ad hoc established and, so, results could significantly be different just changing cut-off values.

In the identification of industrial districts similar questions about discretional cut-off values can be found in methodologies as those developed in Italy by Ministry of Industry in its Law of April 21th of 1993[14] for the identification of industrial districts, the National Institute of Statistics (ISTAT, 1996, 2006) and other proposal as Ybarra

[14] To simplify the identification process, №140 Law of May 11th was approved in 1999. This law introduced some changes in the requirements for the recognition as industrial districts. The main reason was the difficulties found by some regions to get approved their proposals of industrial districts.

(1991) for Spanish industrial districts or Lainé (2000) in France. All these methodologies have in common the use of discrete values (1,0) for each one of the criteria that have to be fulfilled. Problems using these methodologies arise when researchers take the decision about the number of criteria that an agglomeration has to fulfil in order to be named as an industrial district. To solve the arbitrary decisions multivariate analysis or spatial econometric techniques (as LISA indicators explained above) can be used to identify industrial agglomerations as industrial districts or clusters.

In addition, these methodologies applied to identify industrial districts could not been suitable to identify technological districts because the differences between these two types of agglomerations. Which are these differences? Industrial districts have been usually identified because the high degree of industrial activity in a geographical area whereas technological districts tend to be located in metropolitan areas where the industrial activity is not predominant in their economic structures. Also, industrial districts are related to external economies that come up because the agglomeration of enterprises while the development of technological districts is more linked with economies of diversification. Therefore, a location quotient or the estimation of scale economies through variables as employment or number of firms could not be suitable for identifying technological districts because the diversified economic structure of metropolitan areas. On the other hand, one of the main characteristics of industrial districts is the high degree of spatial concentration of firms, so, proximity between firms becomes an important fact. However, for firms inside technological districts distance is not as relevant as for firms at industrial districts. Finally, predominance of small and medium-sized firms is one of the main elements to identify an industrial district but not for technological districts. Systems with a diversified distribution of firm size could be identified as technological districts but not as industrial districts because the need of a predominance of small and medium-sized firms.

Therefore, it could be complex to apply for technological districts the same criteria established to define traditional industrial districts. So, qualitative methodologies have been recently introduced as a new approach for identifying technological districts. Proposals by agents (firms, research centres, training centres...) of recognition as a technological district must be approved by public administration. This is the way used in Italy, for example, through the application of the innovation policy by the Ministry of Education, Universities and Research (MIUR). In a similar way, the Spanish Ministry of

Industry, Tourism and Commerce (MITYC) introduced the figure of Innovative Firm Associations (Agrupaciones de Empresas Innovadoras-AEI) as well as Competitive Clusters (Pôles de Compétitivité) by the French Ministry of Economy, Finance and Industry (MINEFI). All these policy instruments have been designed to support competitiveness of industrial sectors and to promote the development of high technology activities in their respective countries. These strategies are based on the idea that a district must be defined by their own members. So, proposals of recognition are evaluated by public administrations with information from all interested agents about district structure, characteristics of its members, future projects of innovation or the investment attractiveness of the area. Nowadays, 29 Technological Districts in Italy[15], 71 Competitive Clusters in France[16] and 107 Innovative Firms Associations in Spain[17] have been recognized. Provinces or regions, and in some cases local labour systems, have been the main spatial units recognized as technological areas.

In short, the identification of technological districts means the recognition of the importance of these areas that can foster the economic development. Despite the importance of these areas, there are few researchs dealing with quantitative methodologies.

So, the main aim of this research is to identify technological districts in Spain trying to get around the problems explained in this section about the use of quantitative methodologies.

4. Identification of technological districts in Spain: a multivariate analysis

The growing interest in technological districts as key elements for public policies to promote innovation and competitiveness leads to identify these areas in Spain. A first step to identify these areas is to analyse some factors that are directly related to the specialization in high technology activities. Following the research by Lazzeroni (2004), five indicators are used to identify technological districts. Values for these five indicators must be higher than national average and all indicators must be fulfilled in order to identify a technological district. Indicators are defined as follow:

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[15] An official list of technological districts from MIUR is available at the following link: http://www.distretti-tecnologici.it/home.htm.

[16] Competitive Clusters recognized in France by the "Comité interministériel de l'Aménagement et de la Compétitivité des Territoires (CIACT)" is available at the following link: http://competitivite.gouv.fr/poles-en-action/annuaire-des-poles-20.html.

[17] The official register of Innovative Firms Associations from the Ministry of Industry is available at: http://www.ipyme.org/es-ES/SubvencionesAyudas/AEI/ListadoAEI/Paginas/ListaAEI.aspx.

- Specialization index in high technology activities.
    - I1: High and medium technology activities (high and medium technology manufacturing and high technology services)
    - I2: High technology activities (high technology manufacturing and high technology services).
- Share of population with specific training/education in technological or scientific fields (I3).
- Share of employees in technological and scientific areas (I4)
- Net firm birth rate (I5).

Data set is obtained from SABI (Analysis System of Iberian Accounts), Population Census for 2001 of National Statistics Institute (INE) and the Economic 2009 Yearbook of La Caixa. Three-digit level is used as well as the high and medium technology classification of INE (high and medium technology manufacturing sectors and high technology services). On the other hand, local labour systems (LLS) identified by the Spanish Ministry of Industry (Boix and Galleto, 2004) will be the spatial units used in this research. 435 LLS of a total number of 806 LLS in Spain have employment in technology activities; therefore, the analysis will be limited to these areas.

Table 2 includes descriptive statistics for the five indicators explained at the beginning of the section and values for these variables are shown in Tables 3 and 4. Both tables include just LLS that have a result higher than national average for four of five indicators. As it can be seen, Table 3 shows the results of I1 and I2 specialization indexes while Table 4 shows indicators for what is called "system innovation", that is, share of population with specific training/education in technological or scientific areas[18], high technology employment[19] and net firm birth rate[20] (note that national average value is standardized to 100). Last column in both tables shows the average value for the indexes analysed in each table (M1 and M2).

[18] Share of population with degrees in the following areas: computer science, engineering, technical training and industries, sciences and architecture. Source: Population Census 2001 (INE).

[19] Employment in scientific and technological areas: employees with degrees (three to five-years degrees) in physics, chemistry, mathematics and engineerings and teachers at universities and other higher education centres. Source: Population Census 2001 (INE).

[20] Net firm birth rate is calculated for the period 2003-2008. Source: Economic Yearbook 2009 of La Caixa.

Table 2. Descriptive statistics.

	Average	Standard deviation	Variation Coefficient	Maximum	Minimum
Specialization index in high and medium technology activities (%)	5,28	3,62	0,68	24,28	0,02
Specialization index in high technology activities (%)	2,62	1,28	0,49	14,43	0,01
Population with training/education in technological and scientific fields (%)	6,73	2,52	0,37	16,86	0,90
Employment in technological or scientific areas (%) (I4)	1,08	0,36	0,33	2,46	0,03
Net firm birth rate (%) (I5)	10,51	11,34	1,08	55,63	-22,03
n=435					

Source: SABI, Population Census 2001 (INE), Economic Yearbook 2009 of La Caixa and author's elaboration.

Table 3. Specialization Index in High and Medium Technology.

Local Labour System (main municipality)	High and Medium Technology Specialization Index (I1)	High Technology Specialization Index (I2)	Average Index of High Technology Specialization (M1)
Sabiñánigo	241,4	444,0	342,7
Burgos	113,7	16,8	65,2
Valladolid	193,7	32,4	113,1
Barcelona	183,7	158,2	170,9
Sabadell	169,0	127,3	148,2
Madrid	259,9	411,9	335,9
Tudela	150,9	132,3	141,6
Pamplona/Iruña	234,5	88,6	161,5
Peralta	459,8	179,7	319,8
Vitoria-Gasteiz	204,0	201,1	202,5
Donostia-San Sebastián	117,6	135,1	126,3
Bilbao	127,0	140,5	133,8
Logroño	108,6	45,2	76,9
National Average	100,0	100,0	100,0

Source: SABI and author's elaboration.

As it can be seen in Table 3, LLS of Madrid, Vitoria and Barcelona are in the top ranking followed by LLS of Pamplona, Sabadell, Bilbao and San Sebastián. Notice that all LLS are in Catalonia, the Basque Country and Madrid (this LLS covers the entire

region) except Pamplona that belongs to the region of Navarra although share regional borders with the Basque Country.
Considering the results obtained in Table 4 for innovation degree in the LLS analysed, LLS of Madrid and Vitoria are again ranked in the top along with LLS of Pamplona. However, only three LLS fulfil all the criteria used in this methodology, that is, values of the five indexes are higher than the national average: Madrid, Vitoria and Sabadell.

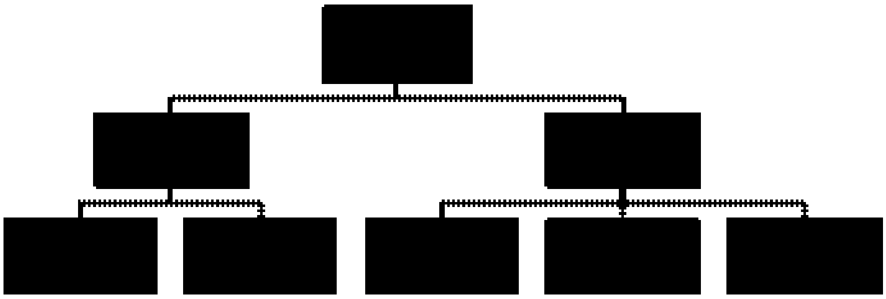
Table 4. Indicators of innovation in local systems.

Local Labour System (main municipality)	% of population with training/education in technological and/or scientific fields (I3)	% of employment in technological and/or scientific areas (I4)	Net firm birth rate (I5)	Average index of system innovation (M2)
Sabiñánigo	140,0	108,5	40,7	96,4
Burgos	163,7	142,2	127,3	144,4
Valladolid	146,2	148,4	111,9	135,5
Barcelona	131,6	146,6	66,8	115,0
Sabadell	122,1	140,8	115,5	126,2
Madrid	134,5	226,9	147,3	169,5
Tudela	123,1	83,7	412,3	206,4
Pamplona/Iruña	173,7	165,5	195,6	178,2
Peralta	116,6	53,9	529,1	233,2
Vitoria-Gasteiz	195,9	145,7	119,9	153,9
Donostia-San Sebastián	184,3	147,3	5,2	112,3
Bilbao	172,5	149,0	96,6	139,4
Logroño	137,2	102,8	121,4	120,5
National Average	100,0	100,0	100,0	100,0

Source: Population Census 2001 (INE), Economic Yearbook 2009 of La Caixa and author's elaboration.

Figure 1 summarizes the results after applying the methodology to identify technological districts. Lowest level in the figure shows the total number of LLS that satisfy each of the five indexes used here. As just three LLS fulfil all criteria (Madrid, Vitoria and Sabadell), the conclusion is that this methodology is very strict because leaves out of the top ranking LLS as Barcelona or Pamplona that have been highlighted as part of the main innovation clusters in the EU[21]. So, we introduce an alternative methodology based on multivariate analysis to get over this restriction.

Figure 1. Identification process of technological districts.



From the available multivariate techniques, factor analysis reduces dimension of observed variables. Thus, factors generated will be the reference to create a synthetic index that will capture most of the information about the original variables. A factor analysis (principal component factor analysis with varimax rotation) is applied to get factors explaining the maximum variance of original variables (I1 to I5). The analysis results in two factors explaining a high percentage of the variance of observed variables; first factor explains near the 50% of the variance.

Next step at this point is to analyse correlations between the two factors and the original variables. Table 5 shows how first factor is correlated to specialization indexes in high and medium technology (I1 and I2) and the share of population with training/education in technological and/or scientific fields. On the other hand, significant correlation is given between second factor and net growth rate of firms (I5).

Table 5. Correlation matrix of factors and original variables.

	Components	
Original variables	1	2
Specialization index in high and medium technology activities (I1)	0,884	
Specialization index in high technology activities (I2)	0,866	
Population with training/education in technological and scientific fields (I3)	0,704	
Employment in technological or scientific areas (I4)	0,535	0,456
Net firm birth rate (I5)		0,917

Note: Only absolutes values over 0,300 are shown. Source: SABI, Population Census 2001 (INE), Economic Yearbook 2009 of La Caixa and author's elaboration.

[21] See Hugo, E. et al. (2007): "Looking Inwards, Reaching Outwards. The Cambridge Cluster Report – 2007"; The Library House Ltd. Cambridge; "Innovation Scoreboard 2003" en http://trendchart.cordis.lu/scoreboard2003/html/methodology.html

Finally, factor analysis allows the generation of punctuations for each LLS that will be used to calculate a synthetic index. As punctuations can have a wide range of variation, a normalized range [0,1] will be used in order to work with homogenized values of punctuations. Thus, 1 will be assigned to LLS with the highest punctuation and 0 to the LLS with the lowest value. Synthetic index for each LLS will be calculated as the Euclidean distance from each LLS to the best LLS, that is the LLS with a normalized value of 1. Euclidean distance measures the shortest distance between two points, that is, the norm of a vector. Thus, distance between point A_i (LLS) and best point A* will be defined as follows:

$$d_2 (A_i,A^*) = [\Sigma\, w_j\, (x_{ij} - x_j^*)^2]^{1/2}$$

where:

A_i = alternative i

A^* = best point where each element has the highest values.

$A^* = (x_1^*, x_2^* \ldots\ldots x_{n^*})$ with $x_j^* = \max\, (U_j(x_{ij}))$

$U_j(x_{ij})$ is defined as a utility function related to element j. So, punctuations will be considered in this function.

W_j = weights of the elements that represent their relative importance[22]

The application of this formula gives as a result a synthetic index that summarizes all information about each LLS. Once calculated this index a ranking of LLS can be established but some rules must be defined. First, average distance to best point is calculated and those LLS will be listed if their values are under this average. In addition, a critical employment level is required and this level must be higher than the value given by a homogeneous distribution of employment for all 435 LLS[23].

Using synthetic index and the minimum level of employment (1945 employees), four different groups of LLS can be identified (Table 6). First group includes 39 LLS that have a high specialization degree in high and medium technology activities as well as an important employment level over the total national sector. Therefore, LLS of this group will be considered as technological districts. If industrial districts are characterized by their specialization in a specific industrial activity and a high concentration of

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[22] Weights are obtained through the factor analysis and are the percentages of standard variation of observed variables that can be explained.

[23] Average represents a homogeneous distribution of employment (1/435)*100 and is equal to 1945 employees.

employment in relation to total employment, these LLS included in the first group share same characteristics. So, these LLS can be defined as technological districts.

Second group consists of LLS with a high specialization degree in high and medium technology activities although critical employment level is not achieved. Despite their specialization, these LLS represent a low percentage of total employment of high technology activities so it is not recommended identifying them as technological districts. Finally, third group comprises remaining LLS that neither have a high specialization degree in high technology activities nor concentrate in their territories at least the minimum level of employment considered as critical at national level. It is worth mentioning that any of the LLS included in the analysis report are not specialized in high technology and have an employment level over national average.

Table 6. Classification of LLS according to multivariate analysis

	SI < AVERAGE (0,755)	SI > AVERAGE (0,755)
% of high and medium technology employment over national total > AVERAGE (0,230)	GROUP 1- 39 LLS	NO CASES
% of high and medium technology employment over national total < AVERAGE (0,230)	GROUP 2- 126 LLS	GROUP 3- 270 LLS

Note: SI: Synthetic index. Source: SABI, Population Census 2001 (INE), Economic Yearbook 2009 of La Caixa and author's elaboration.

Therefore, 39 technological districts concentrate 88.5% of total employment in medium technology activities and 94.2% of high technology employment at national level (see Table 7). In addition, 70.6% of national total population with training/education in scientific or technological fields is concentrated in these technological districts as well as 79.5% of total employment level in these fields. About the economic structure of these areas, percentages of employment and people with training/education in high technology activities in relation to the total employment and population of these geographical areas are particularly significant (8.4% for both variables). To sum up, these 39 technological districts are the most important technological and scientific areas in Spain due to a high degree of specialization and the concentration of highly qualified employees.

Table 7. Main data about LLS.

Variable		Group 1 (39 LLS)	Group 2 (126 LLS)	Group 3 (270 LLS)
% of national total	Employment in High and Medium Technology	88,5	8,6	2,9
	Employment in High Technology	94,2	4,5	1,3
	Population with training/education in technological and/or scientific areas	70,6	18,7	10,7
	Employees in technological and/or scientific areas	79,5	14,5	6,0
	Net firm birth rate			
Specialization degree (% of employment of total group employment; % of population of total group population)	Employment in High and Medium Technology	8,4	2,7	0,9
	Employment in High Technology	4,5	0,7	0,2
	Population with training/education in technological and/or scientific areas	8,4	6,9	4,0
	Employees in technological and/or scientific areas	1,6	0,9	0,4
	Net firm birth rate			
Relative Specialization (national average =100)	Employment in High and Medium Technology	158,3	50,8	17,8
	Employment in High Technology	171,4	27,1	8,0
	Population with training/education in technological and/or scientific areas	124,3	102,4	59,1
	Employees in technological and/or scientific areas	145,9	83,1	34,7
	Net firm birth rate	115,8	104,5	60,1

Source: SABI, Population Census 2001 (INE), Economic Yearbook 2009 of La Caixa and author's elaboration.

Table 8 lists the 39 technological districts identified in Spain. Information about the region and the main municipality of each LLS is included as well as values for the synthetic index and the share of employment in high technology activities. Beside each of two columns a ranking is introduced for each variable. As it can be seen, Madrid is in first position in both rankings followed by LLS of Vitoria, Pamplona, Zaragoza, Barcelona and Bilbao. Madrid and Barcelona concentrate more than a half of total employment in high and medium technology activities. Other LLS as Zaragoza, Bilbao, Sabadell or Valencia are also important because their level of employment. Through an analysis of the list, it can be observed that 23 LLS have a province capital as a centre. Average population of LLS is more than a half million inhabitants with 34 LLS with more than 100000 inhabitants. These results point to the importance of urban economies for technological districts. To support this, average density population of technological districts (503.8 inhab./km^2) is six times the national average. Finally, the nearness of some technological districts can form a spatial conglomerate. For example, 7 technological districts have been identified in the province of Barcelona as well as 3 districts in the case of the province of Guipúzcoa. In addition, there are other five cases where two technological districts are located in the same province.

Table 8. Technological Districts in Spain. Main results.

Region	LLS (main municipality)	Province	SI	RK1	% H&M Tech Empl.(*)	RK2
Andalucía	Puerto de Santa María (El)	Cádiz	0,45	14	0,36	25
	Cádiz	Cádiz	0,57	26	0,43	23
	Granada	Granada	0,61	31	0,26	36
	Martos	Jaén	0,62	33	0,25	37
	Málaga	Málaga	0,66	36	0,52	17
	Sevilla	Sevilla	0,55	24	1,39	10
Aragón	Zaragoza	Zaragoza	0,31	4	5,39	3
Asturias	Gijón	Asturias	0,52	20	0,30	33
	Oviedo	Asturias	0,53	21	0,35	27
Baleares	Palma de Mallorca	Baleares	0,71	38	0,34	28
Canarias	Palmas de Gran Canaria (Las)	Gran Canaria	0,71	39	0,30	32
Cantabria	Santander	Cantabria	0,48	16	0,86	14
Castilla y León	Valladolid	Valladolid	0,39	10	1,87	8
	Burgos	Burgos	0,44	11	0,51	18
Castilla-La Mancha	Guadalajara	Guadalajara	0,48	17	0,31	30
Cataluña	Mataró	Barcelona	0,58	28	0,31	31
	Barcelona	Barcelona	0,32	5	15,26	2
	Manresa	Barcelona	0,51	19	0,62	16
	Vic	Barcelona	0,58	27	0,35	26
	Granollers	Barcelona	0,44	12	1,59	9
	Sabadell	Barcelona	0,35	7	2,71	5
	Vilafranca del Penedès	Barcelona	0,55	23	0,40	24
Com. Valenciana	Alicante	Alicante	0,62	32	0,43	22
	Castellón de la Plana	Castellón de la Plana	0,64	34	0,34	29
	Villarreal/Vila-real	Castellón de la Plana	0,68	37	0,27	35
	Valencia	Valencia	0,56	25	2,41	6
	Llíria	Valencia	0,48	15	0,28	34
Galicia	Coruña (A)	Coruña (A)	0,59	29	0,43	21
	Santiago de Compostela	Coruña (A)	0,54	22	0,24	39

Region	LLS (main municipality)	Province	SI	RK1	% H&M Tech Empl.(*)	RK2
	Vigo	Pontevedra	0,60	30	1,33	11
Madrid	Madrid	Madrid	0,00	1	38,74	1
Murcia	Murcia	Murcia	0,65	35	0,51	19
Navarra	Pamplona/Iruña	Pamplona/Iruña	0,25	3	1,89	7
País Vasco	Vitoria-Gasteiz	Alava	0,21	2	1,31	12
	Donostia-San Sebastián	Guipúzcoa	0,37	8	1,02	13
	Arrasate o Mondragón	Guipúzcoa	0,38	9	0,24	38
	Eibar	Guipúzcoa	0,44	13	0,80	15
	Bilbao	Vizcaya	0,32	6	3,13	4
La Rioja	Logroño	La Rioja	0,50	18	0,48	20

Note: SI: Synthetic Index; RK1: Ranking according to value of synthetic index; RK2: ranking according to level of employment in high and medium technology. (*): Share of employment in high and medium technology of national total.

Source: SABI, Population Census 2001 (INE), Economic Yearbook 2009 of La Caixa and author's elaboration.

5. Concluding remarks

In the last years, geographical areas with a significant specialization in high technology activities have been included in policy measures to support competitiveness in different countries. The development of these policies implies to know where are located these activities and to identify those areas with a high concentration of firms. Thus, empirical contributions about identification of technological districts that have been done at the moment are based on quantitative methodologies using variables as number of establishments, employment, specialization degree or percentage of SMEs. However, these methodologies have some limitations when are applied to identify technological districts instead of industrial districts. Specifically, delimitation of high technology sectors and the suitable spatial unit of analysis are the main difficulties analyzed in this research and the use of criteria that might be fulfilled has been likewise highlighted.

In short, the process of identification of technological districts shows how some areas could not be recognized as technological district because the restrictions imposed by the cut-off values of quantitative variables. The analysis of technological districts in Spain, following the methodology applied by Lazzeroni (2004) in Italy, has identified just 3 LLS (Madrid, Vitoria and Sabadell). Other LLS as Barcelona, Zaragoza, Pamplona or Bilbao are not identified in spite of their relevance in high technology activities at national level. Therefore, to solve the limitations of this methodology a multivariate analysis is used to calculate a synthetic index that allows the identification of technological districts. Through the application of this second analysis 39 LLS in Spain can be defined as technological districts. These areas show a high specialization degree in high and medium technology activities and a great relevance for these activities at national level. Almost 90% of total employment in high and medium technology activities is concentrated in these areas as well as 70% of population with training/education in scientific or technological fields.

Summing up, the methodology used in this research has provided a map of technological districts in Spain. The geographical concentration of high and medium technology manufacturing firms and high technology services firms and research centres providing new flows of scientific and technological knowledge to these firms boosts innovation spreading it over the territory. Despite limitations of quantitative methodologies, the results obtained in our analysis suppose a contribution to improve the knowledge about technological districts and to highlight their relevance for competitiveness policies.

It was expected, with a high probability, that Madrid and Barcelona were identified as technological districts because the concentration of technological firms and, specially, multinational firms. So, the focus for future researchs must be to analyse the characteristics not only of these metropolitan areas but, specially, the structure of activities in the rest of technological districts. This will enhance the knowledge about the opportunities of economic growth for the future and could be used for the design of regional policies.

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